Evaluation of Beam Profiles between Physical and Enhanced Dynamic Wedges

[1]Bahalul Hasan, [1]Md. Sunny Anam Chowdhury, [1]Sujon Mahmud, [1]Md. Nazmul Hossain, [1]Fariha Zerin, [2]Abul Hasnat, [2]Masud Parvej, [3]Mokhlesur Rahman, [3]Fatema Nasreen

[1]Institute of Nuclear Medicine & Allied Sciences, Kushtia

[2]Institute of Nuclear Medical Physics, BAEC, Savar, Dhaka, Bangladesh

[3]Department of Medical Physics and Biomedical Engineering, Gono Bishwabidyalay

Correspondence Address : Bahalul Hasan, Scientific Officer, INMAS, Kushtia, Kushtia Medical College & Hospital Campus, Kushtia- 7000, E-mail: bhaasan26@gmail.com

ABSTRACT

Background: The purpose of the work is to find out the beam profiles using physical and enhanced wedges of different angles, different field sizes, and different energies and to compare them.

Materials and Methods: The study was conducted using the Varian Clinac iX LINAC with different photon energies—6 MV and 15 MV. The slab phantom is arranged at a fixed depth (10 cm depth) above the IBA MatriXX device, which consists of 1020 vented ion chamber 2D array detectors arranged in a 32 × 32 grid. The physical and enhanced dynamic wedges at different angles (15°, 30°, 45°, and 60°) were examined for the field sizes 5x5 cm², 10x10 cm², 10x115×15 cm² by delivering 50 monitoring units (MU).

Result: In comparison of beam profiles (without rescaling) of PW and DW obtained from 2D array measurement, it was found that there was a difference, but the gradient of curves is almost the same except for some points in the toe, heel, and penumbral region, which is negligible. From the beam profiles, it was understood that a. The difference between PW and DW increased with the increase of wedge angle while field size and energy were fixed. b. The difference between PW and DW increased with increasing field sizes while energy and wedge angle were fixed. c. The difference between PW and DW increased with increasing energy while field size and wedge angle were fixed.

Conclusion: Based on the results of our study, it can be concluded that the Universal detector 2D array (matrix) can be used effectively to obtain the dosimetric characteristics of both EDW and physical wedges.

Keywords: Physical Wedge, Enhanced Dynamic Wedge, MatriXX, Beam profile

Bangladesh J. Nucl. Med. Vol. 28 No. 2 July 2025

DOI: https://doi.org/10.3329/bjnm.v28i2.89111

INTRODUCTION

Though the first teletherapy (Co-60) machine was installed in Bangladesh in 1953. But the first linear accelerator (LINAC) machine was installed at the National Institute of Cancer Research & Hospital (NICRH) in Dhaka in 2010 (1). The linear accelerator (LINAC) is a device that produces the photon and electron beams of high energy. The collimated beam emerging from an x-ray tube can be directly applied to the patient. In some circumstances, it is desirable to modify the special distribution of radiation within the patient by the insertion of material into the beam. This is called a beam-modifying device. The wedge is a beam modifier device. Wedge is mainly used to improve dose homogeneity in the target volume. Wedges are used to improve dose homogeneity in the target volume and to modify isodose curve shapes for optimized dose distribution (2).

The aim of this study was to evaluate and compare the beam profiles of physical wedges and enhanced dynamic wedges for different field sizes. Additionally, the study seeks to determine the wedge output factors and to verify the accuracy of commissioning data related to wedge systems.

MATERIALS AND METHODS

For this study, all data of beam profile curves for physical wedges and dynamic wedges are collected from the Department of Radiotherapy, Institute of Nuclear Medical Physics. To complete the work, some equipment must be needed. Such as a LINAC machine, Matrixx phantom, solid/slab phantom, and physical wedge.

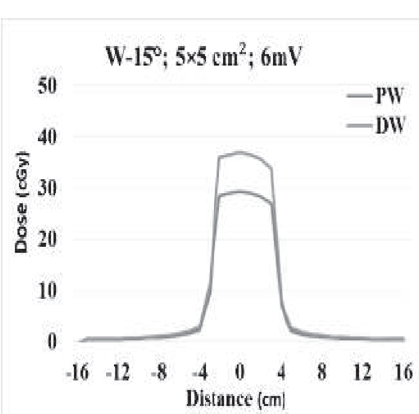
The modern LINAC machine must be needed, which has different photon energies (6 MV, 15 MV). The slab phantom's density is equivalent to water. The thickness of the phantom is about 0.01 to 7 cm. The material can be easily adapted to most ionization chambers [3]. The material of this phantom is very flexible and doesn't break under impact. The matrix is the formation of a 1020 ion chamber array detector. They are placed in a 32×32 lattice. The equivalent absorber thickness on the front side of the matrix is 3.6 mm, and the maximum field of view on the matrix is 28 × 28 cm² (4). The International Commission on Radiation Units and Measurements (ICRU) recommendation for the reference depth is 10 cm (5). There are two types of wedges: physical wedges and dynamic wedges. A physical wedge is usually constructed from a high-density material, such as lead or steel. The wedge filters on the Varian Clinac iX Accelerator have nominal wedge angles of 15°, 30°, 45°, and 60° with four orientations (LEFT, RIGHT, IN, OUT). In the enhanced dynamic wedge technique, no external beam modifier is used to create wedge dose profiles. A physical wedge is mounted on a transparent plastic tray, which can be inserted in the beam at a specified distance from the source. This distance is at least 15 cm from the skin surface to avoid destroying the skin-sparing.

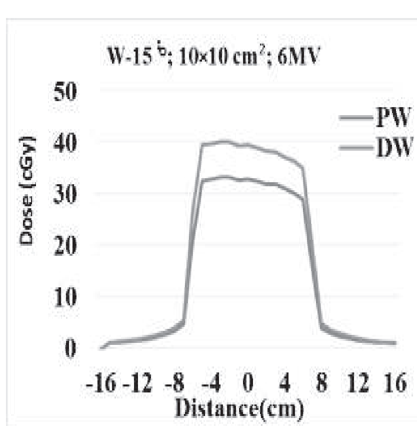
The study was conducted using the Varian clinac iX linear accelerator with different photon energies 6MV and 15MV. Also, the isodose curves calculated by the Eclipse treatment planning system (TPS). The slab phantom arranged at a fixed depth (10cm depth) above the Matrixx phantom. The physical and enhanced dynamic wedges different angles (15°, 30°, 45° and 60°) were examined for the field sizes, 5×5cm², 10×10cm² and 15×15cm². The LINAC machine delivered 50 monitoring unit (MU) each case (6).

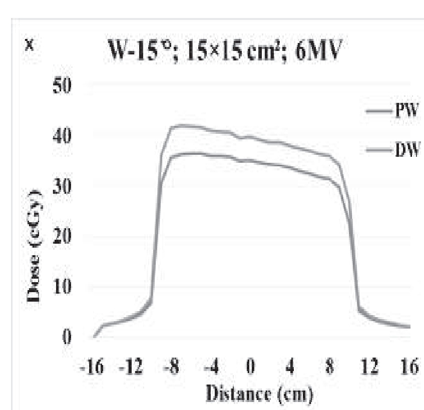
RESULT

Table 1: Variation of measured dose of beam profiles between Physical and Dynamic Wedge for 6MV & 15MV energy at 10cm depth for different field sizes.

Beam Energy (MV)	Field Size (cm×cm)	Variation between PW & DW for different Wedge Angle							
		15°		30°		45°		60°	
		Mean (cGy)	SD	Mean (cGy)	SD	Mean (cGy)	SD	Mean (cGy)	SD
6	5×5	5.34	3.07	8.81	4.61	10.91	5.99	11.86	6.22
	10×10	5.96	1.54	8.52	2.77	10.39	3.60	9.43	3.94
	15×15	4.62	0.96	6.18	1.61	7.27	2.80	4.94	2.80
15	5×5	5.30	3.07	9.41	4.51	13.23	6.75	14.55	7.41
	10×10	5.96	1.50	8.91	2.62	12.48	4.18	12.09	4.41
	15×15	4.54	0.92	6.39	1.54	9.43	2.64	7.26	2.54







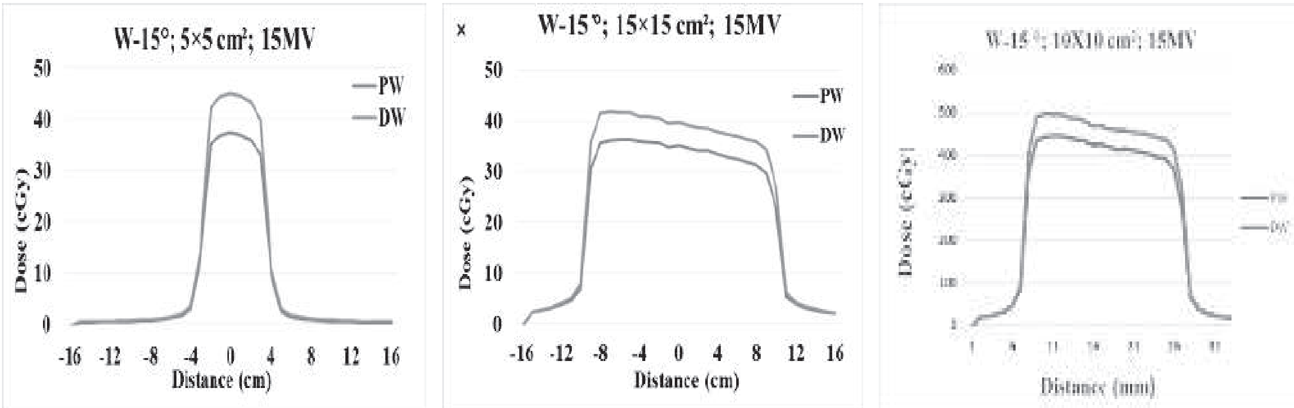


Figure 1: Beam profiles of physical and enhanced dynamic wedge for wedge angle 15°, 6MV energy (Top row) and wedge angle 15°, 15 MV energy (Bottom Row)

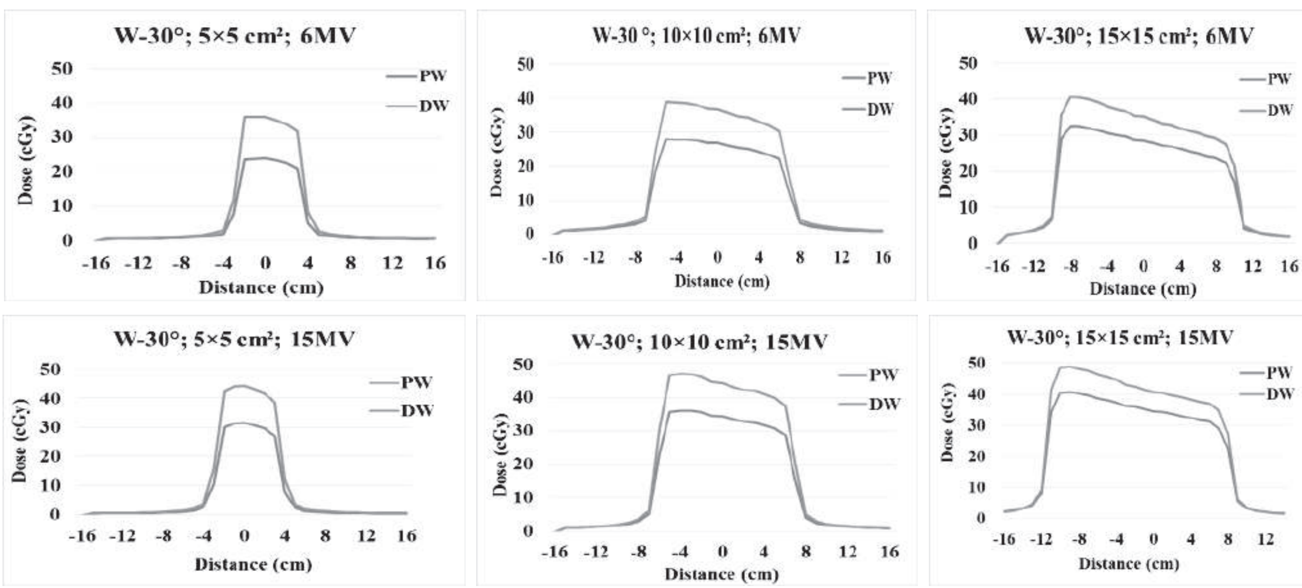


Figure 2: Beam profiles of physical and enhanced dynamic wedge for wedge angle 30°, 6MV energy (Top row) and wedge angle 30°, 15 MV energy (Bottom Row)

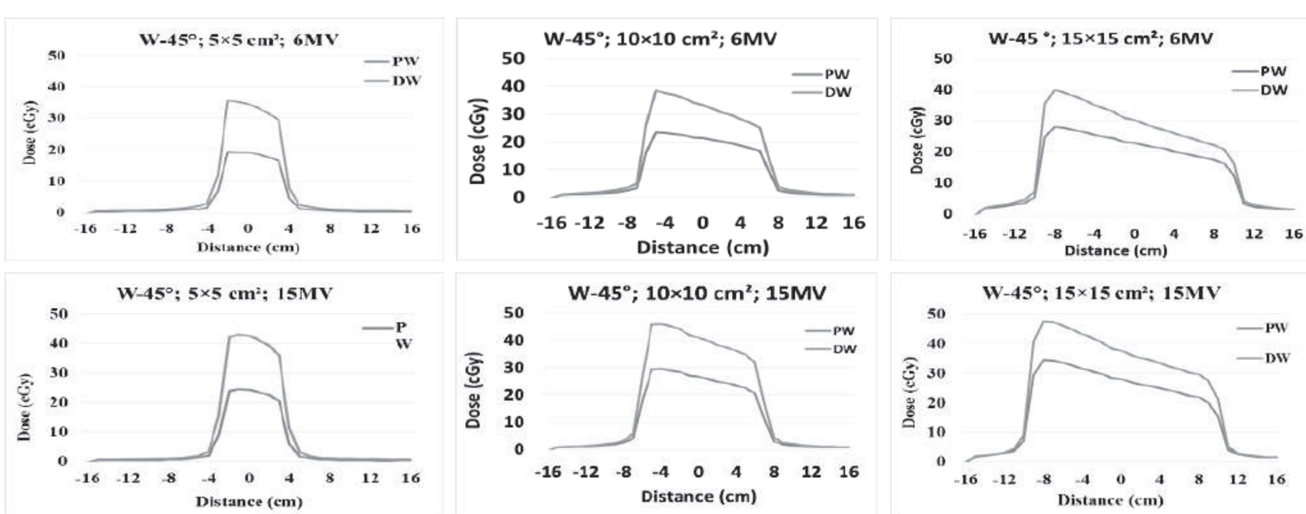


Figure 3: Beam profiles of physical and enhanced dynamic wedge for wedge angle 45°, 6MV energy (Top row) and wedge angle 45°, 15 MV energy (Bottom Row)

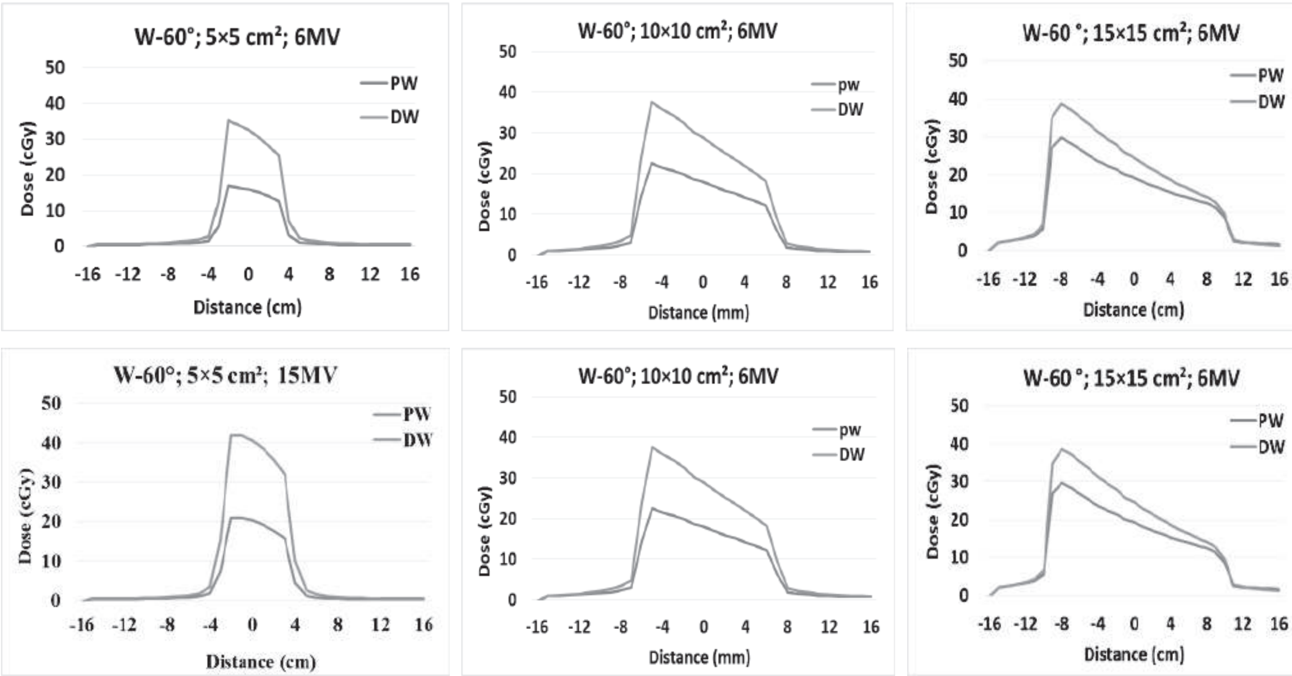


Figure 4: Beam profiles of physical and enhanced dynamic wedge for wedge angle 60°, 6MV energy (Top row) and wedge angle 60°, 15 MV energy (Bottom Row)

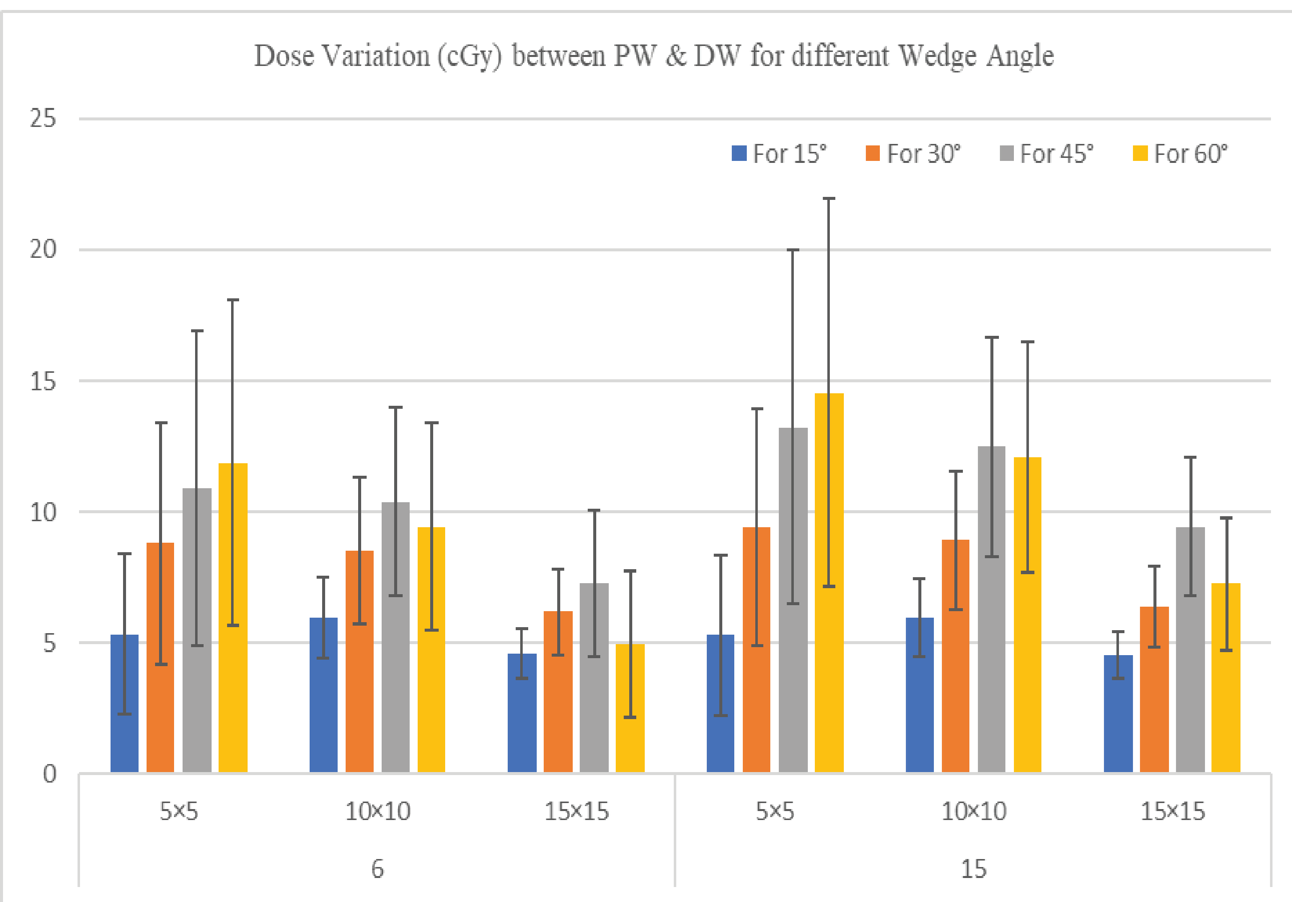


Figure 5: Dose variation (cGy) between PW and DW for different wedge angle.

From the beam profile showed in Table 1 and Figure 1 to 5, it was evident that -

a. The difference between PW and DW increased with the increasing wedge angle while field size and energy were fixed.

b. The difference between PW and DW increased with the increasing of field sizes while energy and wedge angles were fixed.

c. The difference between PW and DW increased with increasing energy while field size and wedge angles were fixed.

DISCUSSION

While this study provides valuable insights, there are limitations such as the fixed depth of the phantom and the use of only specific photon energies and field sizes. Future research could explore a broader range of conditions, including different depths, wedge types, and additional photon energies, to further understand the nuances of dose distribution with various wedges. Overall, the study highlights the importance of comprehensive dosimetric analysis in radiotherapy and the role of advanced measurement tools like the MatriXX in enhancing treatment accuracy and effectiveness.

CONCLUSION

The study confirms that the Universal Detector 2D array (MatriXX) is highly effective for evaluating the dosimetric characteristics of both Enhanced Dynamic Wedges (EDW) and Physical Wedges (PW). Its precision in measuring beam profiles supports accurate dose distribution assessments, aiding in optimized radiotherapy planning and treatment.

REFERENCES

1. Universal Journal of Medical Science.Universal Journal of Medical Science.2017; 5(1): 8–12.
2. Khan FM. Treatment Planning in Radiation Oncology. 4th ed. Elmsford, NY: Pergamon Press; 1989.
3. Klein EE, Low DA, Meigooni AS, Purdy JA. Performance evaluation and quality assurance of Varian enhanced dynamic wedges. Journal of Applied Clinical Medical Physics. 2006; 7: 14–20.
4. Zhu XR, Gillin MT, Jursinic PA, Grimm DF, Lopez F, Rownd JJ. Performance evaluation of a diode array for enhanced dynamic wedge dosimetry. Medical Physics. 1997; 24: 1173–1180.
5. International Commission on Radiation Units and Measurements (ICRU). Determination of absorbed dose in a patient irradiated by beams of X or gamma rays in radiotherapy procedures. ICRU Report 24. Washington, DC: ICRU; 1976. p.12–14.
6. Wiezorek T, Brachwitz T, Georg D, Blank E, Fotina I, Habl G, et al. Comparison of dosimetric characteristics of physical and enhanced dynamic wedges. Reports of Practical Oncology and Radiotherapy. 2012; 17(1): 4–12.